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Single-Shot Charge Readout Using a Cryogenic Heterojunction Bipolar Transistor Preamplifier Inline with a Silicon Single Electron Transistor at Millikelvin Temperatures[1] MATTHEW CURRY, University of New Mexico, TROY ENGLAND, JOEL WENDT, TAMMY PLUYM, MICHAEL LILLY, STEPHEN CARR, MALCOLM CARROLL, Sandia National Laboratories
— Single-shot readout is a requirement for many implementations of quantum information processing. The single-shot readout fidelity is dependent on the signal-to-noise-ratio (SNR) and bandwidth of the readout detection technique. Several different approaches are being pursued to enhance read-out including RF-reflectometry, RF-transmission, parametric amplification, and transistor-based cryogenic preamplification. The transistor-based cryogenic preamplifier is attractive in part because of the reduced experimental complexity compared with the RF techniques. Here we present single-shot charge readout using a cryogenic Heterojunction-Bipolar-Transistor (HBT) inline with a silicon SET charge-sensor at millikelvin temperatures. For the relevant range of HBT DC-biasing, the current gain is 100 to 2000 and the power dissipation is 50 nW to 5 μW, with the microfabricated SET and discrete HBT in an integrated package mounted to the mixing chamber stage of a dilution refrigerator. We experimentally demonstrate a SNR of up to 10 with a bandwidth of 1 MHz, corresponding to a single-shot time-domain charge-sensitivity of approximately 10^{-4} $e/\sqrt{\text{Hz}}$. This measured charge-sensitivity is comparable to the values reported using the RF techniques.

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Matthew Curry
University of New Mexico

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